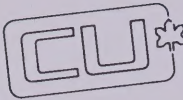


PIPE BURST TESTING PROGRAM

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10 May, 1974

TO: MEMBERS OF THE TECHNICAL COMMITTEE

Gentlemen:

SYSTEM ALTERNATIVE DESIGN STUDIES RE PIPE BURST TESTING PROGRAM

At the special Technical Committee meeting held in Columbus, Ohio on April 30th, it was indicated that we had under study certain system alternative design studies related to the burst test program. Attached for your information is a copy of a letter dated May 8, 1974 prepared by Mr. H. Purcell of NES which provides order of magnitude comparisons of the capabilities and costs for the following two studies:

- a) 48" diameter pipeline systems for different gas compositions and operating pressures. This information was generated to assist the Metallurgical Subcommittee in their planning of future burst tests.
- b) 42" diameter 0.75 W.T., X-70 pipeline system for two different gas compositions and levels of operating temperatures.

In both cases, a comparison of results has been made with the 48" base case.

For your information we are presently working with the Metallurgical Subcommittee towards identifying other alternative systems which should be studied in connection with the burst test program.

Yours very truly,

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J. K. Burrell
J. K. Burrell, P. Eng.
Assistant Director of Engineering

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May 8, 1974

File: 5.1.4

Mr. J. K. Burrell
Canadian Arctic Gas Pipeline Limited
1270 Calgary House
550 - 6th Avenue S. W.
CALGARY, Alberta
T2P 0S2

Dear John:

Burst Cases

This letter summarizes the results of the studies we have performed to date in connection with the potential long-failure problem. The studies are intended to provide guidance to the Metallurgical Subcommittee in their planning of future burst tests, and to provide an order-of-magnitude comparison of the capabilities and costs of 42-inch systems vs. the various 48-inch systems that may be suitable.

We performed flow studies for three 48-inch systems, using the Base Case pipe specification with the exception that an 80 foot-pound shelf energy was used to select the operating pressure (vs. 68 foot-pounds for the Base Case). The operating pressure for each case was supplied by EPR on the basis of the Battelle correlation using the backfilled pipe condition.

The gas compositions for two of the cases were supplied by the producers' Ad Hoc Gas Composition Committee following their investigations into processing techniques that would yield a "leaner" gas from the Prudhoe reservoir fluid and thus allow the operating pressure to be increased. Case 1 uses the same 50-50 Prudhoe Bay - Mackenzie Delta composition as was used in the Base Case; Cases 2 and 3 use progressively leaner compositions as calculated by the producers. It should be noted that the gas compositions as supplied by the producers' Ad Hoc Committee represent compositions which will permit the pipeline system to operate at 1500 psig and 1670 psig respectively. These compositions, however, are not necessarily those which the Ad Hoc Committee will finally recommend. Their studies, which include work to be performed by the Ralph M. Parsons Company, are still in progress and to date no conclusion has been reached as to whether or not it will be feasible for the producers to process the gas to a sales gas specification which matches either of these compositions.

The results of our flow studies for the 48-inch systems are presented on Table 1. The gas compositions used are shown on Table 5. In each Case, we simply calculated the maximum capacity of the Travaillant Lake to Caroline segment of the system using the same compressor station sizes as were used in the Base Case. We believe that the gas volumes thus calculated are reasonably close to optimum for each Case and that no significant change in the results would be produced by using other compressor station sizes.

Cases 2 and 3 were calculated on the basis of station suction and discharge temperatures approximately equal to those of the Base Case (0°F and 12°F respectively). Case 1 was calculated on the basis of 25°F station discharge temperature in order to avoid operating in the two-phase region. Previous studies have shown that the benefits due to the higher allowable operating pressure possible at the higher temperature are almost exactly offset by the penalties due to the higher temperature, and the resulting gas throughput is virtually the same for both temperature ranges.

In order to produce these results as quickly as possible, we did not consider the "warm" portion of the system south of the 60th Parallel. Because the risk of long fractures is significantly reduced at the higher operating temperature, the compression horsepower could be reduced at the lower flows if the 1680 psig operating pressure is maintained, or, alternatively, the pipe wall thickness could be reduced and the horsepower maintained if the operating pressure is reduced. Either of these alternatives would have the effect of reducing somewhat the relative cost-of-service penalties calculated when considering only the northern system, but would not change the ranking of the systems.

We also performed flow studies for a 42-inch by 0.75-inch Grade 70 pipeline system from the Travaillant Lake junction to the 60th Parallel. This pipe size has been suggested by several participants as a possible alternative to the lower-pressure 48-inch system necessitated by the potential long-failure problem.

The 42-inch system was investigated for both the Prudhoe Bay and mixed-gas compositions used in the regulatory filing, as well as for both a 25°F and an 18°F discharge temperature (the latter producing a 0°F suction temperature), as I am not certain which combination of conditions the 1530 psig allowable operating pressure was calculated for.

Table 2 presents the results of the maximum-capacity flow studies, including a comparison with the 48-inch Base Case. The flows were calculated on the assumption that the station locations and sizes would remain the same as the Base Case configuration.

Table 3 shows an estimate of the investment cost for the 42-inch system. The pipeline material cost was reduced from that for the Base Case in proportion to the weights per foot of the two pipe sizes. The five percent reduction in pipeline installation cost for the 42-inch system is our best approximation of the savings. A detailed estimate was not performed.

Table 4 presents a rough financial analysis of the various systems, on the assumptions that the fixed annual charges equal 15 percent of the investment cost and that the operating costs do not change from the Base Case costs.

A comparison can be made between the final lines on Table 4 and Table 1, for the 42-inch and 48-inch systems respectively. The 48-inch Case 1 system and the 42-inch Case 6 system both carry 50-50 gas, as does the Base Case, so that the producers' processing costs can be ignored in making a comparison. The figures tabulated below were extracted from the tables and demonstrate that the 48-inch system is a better choice than the 42-inch system, provided that the gas volumes are available.

	<u>Base Case</u>	<u>48-Inch Case 1</u>	<u>42-Inch Case 6</u>
Maximum Capacity at 60th Parallel, MMcfd	4,714	3,752	3,170
Relative Cost of Service	1.0	1.26	1.43

We will be available to discuss these studies with you at your request.

Yours truly,



Hoyt Purcell

HP/jk
Attch.

TABLE 1

Burst Cases

Comparison of Operating Characteristics
Travaillant Lake to 60th Parallel

	Base Case	Case 1	Case 2	Case 3
Pipe Diameter (in.)	48	48	48	48
Wall Thickness (in.)	0.72	0.72	0.72	0.72
Pipe Energy (C_{v100} -ft-lbs)	68	80	80	80
Gas Composition (see att.)	50-50	50-50	Case I	Case II
Low Heat Value (BTU/cf)	988.41	988.41	935.03	923.79
J-curve Correlation	-	- backfilled condition -		
Maximum Allowable Operating Pressure (psig)	1680	1400	1500	1670
Avg. Sta. Disch. Temp. ($^{\circ}$ F)	12.3	25.4	12.3	12.3
Avg. Sta. Suct. Temp. ($^{\circ}$ F)	-0.1	11.1	0.4	1.1
Avg. Sta. Suct. Pressure (psig)	1,382	1,127	1,230	1,380
Maximum Capacity Under Average Summer Conditions (MMcfd)				
Travaillant Lake Supply	4,844.0	3,875.6	4,253.6	4,663.0
Fuel	130.4	124.0	132.8	136.0
60th Parallel Delivery	4,713.6	3,751.6	4,120.8	4,527.0
Energy Equivalent (BTU $\times 10^9$ /day)				
Travaillant Lake Supply	4,787.9	3,830.7	3,977.2	4,307.6
Fuel	128.9	122.6	124.1	125.6
60th Parallel Delivery	4,659.0	3,708.1	3,853.1	4,182.0
<u>*Relative Cost of Service</u>				
Mcf Basis	<u>1.00</u> 0.796	1.256 <u>1.00</u>	1.144 0.910	1.041 0.829
BTU Basis	<u>1.00</u> 0.796	1.256 <u>1.00</u>	1.209 0.962	1.114 0.887

*Inversely proportional to 60th Parallel delivery

TABLE 2

BURST CASESComparison of Operating Characteristics
Travaillant Lake to 60th Parallel

	Base Case	Case 4	Case 5	Case 6	Case 7
Pipe Diam. (in.)	48	42	42	42	42
Wall Thickness (in.)	0.72	0.75	0.75	0.75	0.75
Pipe Energy (ft.-lb.)	68				
Gas Composition	50-50	-P. Bay Gas "C"-		50-50	50-50
Low Heat Value (BTU/cf)	988.41	1035.91	1035.91	988.41	988.41
J-curve Correlation	-	backfilled condition			
Max. Allow. Opr. Press (psig)	1680	1530	1530	1530	1530
Avg. Sta. Disch. Temp (^o F)	12.3	18.4	25.4	18.4	25.4
Avg. Sta. Suct. Temp (^o F)	-0.1	0.6	6.6	1.7	7.9
Avg. Sta. Suct. Press (psig)	1382	1196	1191	1199	1189
*Max. Capacity under Avg. Summer Cond. (MMcfd)					
Trav. Lake supply	4844.0	3339.1	3280.7	3289.3	3243.1
Fuel	130.4	110.1	113.1	119.1	121.9
60th Parallel Delivery	4713.6	3229.0	3167.6	3170.2	3121.2
Energy Equivalent (BTU x 10 ⁹ /day)					
Trav. Lake Supply	4787.9	3459.0	3398.5	3251.2	3205.5
Fuel	128.9	114.0	117.2	117.7	120.5
60th Parallel Delivery	4659.0	3345.0	3281.3	3133.5	3085.0

*with the Base Case station locations and sizes.

TABLE 3

BURST CASES

Total Escalated Investment Cost-Travaillant
Lake to 60th Parallel

Feature	<u>48" Base Case (\$1,000)</u>	<u>42"/48" Factor</u>	<u>42" x 0.75" (\$1,000)</u>
Land	\$ --		\$ --
Pipeline Material	457,309	0.909	415,694
Pipeline Installation	378,642	0.95	359,710
Pipeline Ancillary Facilities	151,435	1.0	151,435
Station Material	256,967	1.0	256,967
Station Installation	121,819	1.0	121,819
Measuring	--		--
O & M Facilities	27,468	1.0	27,468
Communications	23,496	1.0	23,496
Total Direct Cost	\$1,417,136	(0.957)	\$1,356,589
Pre-Permit Costs	\$ 30,791	1.0	\$ 30,791
O & M Prior to Service	12,014	1.0	12,014
Contingencies	70,856	0.957	67,829
Engineering	85,028	0.957	81,395
Materials & Supplies	11,149	1.0	11,149
Interest during Construction	201,864	0.957	193,184
Working Capital	5,856	1.0	5,856
Financing	27,940	0.957	26,739
Total Indirect Cost	\$ 445,498		\$ 428,957
Total Investment Cost	\$1,862,634		\$1,785,546

TABLE 4

BURST CASES

Simplified Financial Analysis - Base Case
vs. 42" x 0.75" system from Travaillant
Lake to 60th Parallel

	48" Base Case	42" Case 4	42" Case 5	42" Case 6	42" Case 7
Gas Composition	50-50	-P. Bay Gas "C"-		50-50	50-50
Sta. Disch. Temp. (°F)	12.3	18.4	25.4	18.4	25.4
Max. Allow. Opr. Pressure (psig)	1680	1530	1530	1530	1530
Investment Cost (\$ million)	\$1,863	\$1,786	\$1,786	\$1,786	\$1,786
1982 Fuel (85.3% load factor) BTUx10 ¹²	40.1	35.5	36.5	36.6	37.5
<u>Annual Cost of Service</u> (\$ million)					
Fixed Costs at 15% of Investment Cost	\$ 279	\$ 268	\$ 268	\$ 268	\$ 268
1982 Operating Costs	21	21	21	21	21
Fuel at 35c/MMBTU	14	12	13	13	13
Total	\$ 314	\$ 301	\$ 302	\$ 302	\$ 302
<u>Annual Delivery</u> (92.9% load factor)					
Bcf	1598	1095	1074	1075	1058
BTU x 10 ¹²	1580	1134	1113	1063	1046
<u>Cost of Service</u>					
¢ per Mcf	19.6	27.5	28.1	28.1	28.5
¢ per BTU x 10 ⁶	19.9	26.5	27.1	28.4	28.9
<u>Relative Cost of Service</u>					
Mcf Basis	1.00	1.40	1.43	1.43	1.45
BTU Basis	1.00	1.33	1.36	1.43	1.45

TABLE 5

Burst Cases

Gas Compositions

Gas	Mol-Percent			Prudhoe Bay Gas "C"
	<u>50-50</u>	<u>Case I</u>	<u>Case II</u>	
Methane (C1)	89.68	92.690	94.085	85.11
Ethane (C2)	5.22	4.962	3.881	7.70
Propane (C3)	2.45	0.495	0.237	3.99
i Butane (iC4)	0.32	0.012	0.005	0.50
n Butane (nC4)	0.47	0.011	0.004	0.73
i Pentane (iC5)	0.09	0.001 ⁽¹⁾	- ⁽²⁾	0.11
n Pentane (nC5)	0.07	-	-	0.09
Hexane (C6)	0.03	-	-	0.02
Heptanes plus (C7+)	0.02	-	-	-
Carbon Dioxide	1.00	1.014	0.960	1.00
Nitrogen	<u>0.65</u>	<u>0.815</u>	<u>0.828</u>	<u>0.75</u>
	100.00	100.000	100.000	100.00

(1) C5+ in the ratio iC5/nC5/C6 = 10.6/5.6/0.9.

(2) C5+ = 0.0001

Note: The compositions of Case I and Case II gas are preliminary and subject to change following work now in progress, as discussed in the accompanying letter.

The 50-50 and Prudhoe Bay Gas "C" compositions are taken from the CAGPL regulatory application.

May 8/74

Date Due

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